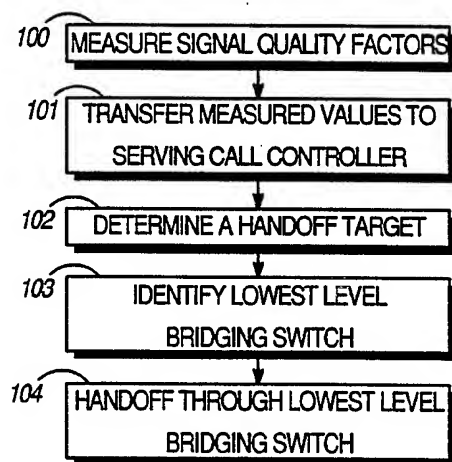




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(54) Title: A METHOD AND APPARATUS FOR PERFORMING HANDOFFS IN A WIRELESS COMMUNICATION SYSTEM

**(57) Abstract**

A method and apparatus of performing handoffs in a cellular communication system, such method including the step of providing a switch at each point in a signal path bridging at least two cells. The method further includes the steps of determining (102) that handoff of a communication transaction from a serving cell to a target cell is indicated and identifying (103) a switch in a signal path to the serving cell bridging the serving and target cells. The method finally includes handing off (104) through the bridging switch. The apparatus of such method of performing handoff (104) includes the inclusion of a switch at each signal distribution point bridging at least two service coverage areas. Handoff within such a system may then be initiated from a serving base site based upon information contained in a means for configuring, and requesting that handoff occur within the switch bridging serving and target cells. The method may also be practiced under matrix switching or packet switching techniques.

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A METHOD AND APPARATUS FOR PERFORMING HANDOFFS IN A WIRELESS COMMUNICATION SYSTEM

5 Field of the Invention

The invention relates to communication systems and in specific to cellular communication systems.

10 Background of the Invention

Cellular communication systems are known. Such communication systems typically provide communication services throughout a relatively large geographic area through a number of base sites, each having a service coverage area. Such base sites are arranged to provide substantially continuous coverage to mobile communication units passing through such area by handing off the source of service from one base site to another as a communication unit passes through the area.

Communication services within the cellular system are provided through exchange of radio frequency (RF) signals between a communication unit and a serving base site. As the communication unit moves out of the service coverage area of the serving base site, the movement is detected by signal measurements performed by the communication unit, and transferred to the serving base site, or, by signal measurements of the communication unit by other, nearby base sites. A determination of a need to handoff a communication transaction, from a serving base site to a new (target) base site proximate the moving communication unit, may be based upon comparison of measured signal values with threshold values. (The Global System for Mobile Communications (GSM), as specified in GSM recommendations available from the European Telecommunications Standards Institute (ETSI) and incorporated herein by reference, is an example of just such a system.)

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Upon determining that a communication unit needs to be handed off from a serving base site to a target base site, a communication path must be established with the communication unit through the target base site. Under the prior art, transfer is accomplished within a matrix switch located at a mobile switching center (MSC) or a matrix switch located at a base site controller (BSC).

The matrix switch within a cellular system provides handover through the availability of interconnects within the switch from a multitude of external signaling devices. In the case of handoff, the matrix switch is provided with interconnects from both serving and target base sites. To accomplish handoff a controller (e.g., the MSC or BSC) for the matrix switch commands the matrix switch to disconnect the path with the original serving cell and reconnect to the target cell or by invoking third-party conferencing features of the cellular infrastructure to bridge the cells for some period of time. Alternatively the controller may command the switch to connect to both target and serving base site for a predetermined time period under a process referred to as "soft handover". Soft handover may occur in some systems through direct control of packet selection or packet switching by a local controller.

Locating the matrix switch at an MSC (or at the MSC and BSC) may require relatively long signal paths between the base site (BS) and matrix switch. If the MSC controls multiple BSCs, or the BSCs control multiple BSs, or the BSs serve multiple sectors, then relatively large numbers of limited-purpose signal paths must be provided between switch and served devices.

The problem of handoff through a matrix switch is complicated where handoff is to a cell that is part of a different cellular system, or part of a different base station system (BSS). If the handoff target base site is served through a different BSC than the original serving site, then handoff must be performed within a matrix switch located at the MSC. Handoff is required at the MSC because neither the matrix switch at the BSC of the serving base site or the

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matrix switch at the BSC of the target base site has interconnects with both serving and target base sites. The matrix switch at the MSC, on the other hand, is provided with interconnects from all BSCs controlled by that MSC. To
5 achieve handoff at the MSC, the MSC commands the MSC matrix switch to interconnect to the target cell and disconnect from the prior, serving cell.

If the target cell site is part of a different cellular system, then handoff may require the involvement of the
10 public switch telephone network (PSTN). Alternatively, handover among different cellular systems may be accomplished through special trunk groups maintained for handover among the different systems. Where different MSCs are involved the MSCs must exchange information on
15 handoff and request handoff from switching systems within the PSTN or use special trunk groups.

While handoffs based upon matrix switches located at the MSC or BSC have worked well, such an arrangement is inefficient because of the distance and number of signal
20 paths brought to centralized locations, remote from the devices served. A need exists for a method of localizing handoff to the devices directly involved in the handoff.

25 Summary of the Invention

A method and apparatus of performing handoffs in a cellular communication system, such method including the step of providing a switch at each point in a signal path
30 bridging at least two cells. The method further includes the steps of determining that handoff of a communication unit from a serving cell to a target cell is indicated and identifying a switch in a signal path to the serving cell bridging the serving and target cells. The method finally
35 includes handing off through the bridging switch.

The apparatus of such method of performing handoff includes the inclusion of a switch at each signal distribution point bridging at least two service coverage areas. Handoff

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within such a system may then be initiated from a serving base site based upon information contained in a means for configuring, and requesting that handoff occur within the switch bridging serving and target cells.

5

Brief Description of the Drawings

10 FIG. 1 depicts a block diagram of a cellular communication system, in accordance with one embodiment of the invention.

15 FIG. 2 depicts a prior art matrix switch.

FIG. 3 depicts a base station system, in accordance with the preferred embodiment with a switch at each circuit branch point.

20 FIG. 4 depicts a block diagram of a communication unit, in accordance with the invention.

25 FIG. 5 depicts a flow chart of handoff in accordance with the preferred embodiment of the invention.

Detailed Description of the Preferred Embodiment

30 The solution to the problem of localizing handoff lies, conceptually, in placing a switch at each signal distribution point bridging more than one service coverage area. The switch may be placed at a BS serving multiple sectors or with a transcoder serving multiple BSSs. Placement of a switch at such a signal distribution point allows handoff
35 through the lowest level of the system, without involvement of other levels. Relegation of handoff activity to low level, signal branch points beneficially reduces the potential of call blocking, on handover, while increasing

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system capacity. Relegation of handoff to low level branch points may also allow handoff determinations based upon signal quality information available at low level branch point (e.g., a base site) that may not be available at higher level branch points (e.g., an MSC).

Shown in FIG. 1 is a cellular communication system, generally (10), in accordance with one embodiment of the invention. Included within such a system (10) are MSCs #1-j (10 and 11). Each MSC of MSCs #1-j (e.g., MSC #1) may have associated with it transcoders #1-k (12 and 13). Each transcoder (e.g., transcoder #1), of transcoders #1-k (12 and 13), in turn, services BSCs #1-m (15 and 16). Each BSC (e.g., BSC #1) of BSCs #1-m controls BSs #1-n (18 and 19). Each BS (e.g., BS #1 (18)) of BSs #1-n (18 and 19) provide communication services within a number of sectors (cells) (22-24).

Shown in FIG. 2 is a means for switching (34) that, under the preferred embodiment, is included within MSCs (10 and 11), transcoders (12-14), BSCs (15-17) and BSs (18-21). The means for switching (switch) may be a circuit switch (matrix switch) or packet switch. The switch (34) (as known in the art) is capable of providing a path (within the switch (34)) between any two external connections (1-q). If the switch (34) is a packet switch, then the path may be created by reference to a header within a transmitted data packet or created under external control (fast packet switching). If the switch (34) is a matrix switch, then the circuit path is created under control of an external processor. Inclusion of the switch (34) within each MSC (10 and 11), transcoder (12-14), BSC (15-17) and BS (18-21) beneficially allows handoff to occur at the lowest possible level within the system (10). Because of varying needs and switching applications within the system (10) packet switching and circuit switching may exist simultaneously within different levels of the same system (10).

Allowing handoff to occur at the lowest possible level within a system (10) reduces function-specific interconnect wiring within such a system (10) by placing a switch (34)

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at each branch point associated with two or more service coverage areas. Locating a switch (34) at each branch point allows trunking to occur to the lowest possible level thereby increasing overall system efficiency. Locating the switch at such branch points may also localize control traffic to the branch point in cases where the handoff controller (call controller) is also located at the branch point.

Shown in FIG. 5 is a flow chart of handoff in accordance with the preferred embodiment of the invention. Reference will be made to the flow chart as appropriate to understanding the invention.

By way of example a communication unit (50, FIG 3) is exchanging a communicated signal with a public switch telephone network (PSTN) subscriber (not shown) on an allocated frequency f_1 . During call set-up, the switch (34) within the BS (18) is commanded to establish a signal path between terminals 1 and $p+3$. The switch (34) within the call controller (BSC 15) is commanded to establish a signal path between terminals 1 and $p+2$. The switches (34) within the transcoder (12) and MSC (10) (not shown) are similarly configured.

During the exchange the communication unit (50) moves out of cell 22 and into cell 23. Determination of a need for handoff within such a system (10) may be determined, in part, by comparison of measured signal values with threshold values. Under GSM, a scanner (43) within the communication unit (50, FIG. 4) measures (100) a signal quality factor (such as signal strength) of control signals of surrounding cells (23 and 24) and transfers (101) such measurements to the call controller (BSC 15) for a determination of handoff. Within other systems a scanner (28) located at a base site (18 or 19) measures (100) signal quality factors of the communication unit (50) within cells (22-27) surrounding the serving cell and transfers such measurements to the call controller (BSC 15).

The BSC (15) upon receipt of signal quality measurements determines a need to handoff and a handoff

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target (102) based upon the transferred signal quality measurements. Upon determination of a need for handoff, the BSC (15) commands the communication unit (50) to handoff to the target on the same or another frequency f_2 .

- 5 The BSC (15) also determines (103) by reference to a means for configuring (36) (e.g., a look-up table or algorithm) that the lowest-level signal branching point, serving both serving (22) and target (23) cells, is the switch (34) located at the BS (18). Upon such determination the BSC (15)
- 10 commands the switch (34) at the BS (18) to handoff (104) the communication unit (50) by discontinuing the signal path between terminals 1 and $p+3$ and to re-establish a voice path through terminals 1 and $p+2$.

- As the communication unit passes through cell 23 into
- 15 cell 24 the process repeats with the call controller (BSC 15) commanding the switch (34) within the BS (18) to discontinue the path through terminals 1 and $p+2$ and re-establish the path through terminals 1 and $p+1$. The BSC (15), in such case, again identifies the switch (34) within
- 20 the BS (18) as the lowest-level switch (34) by reference to the means for configuring (36) within the BSC (15).

- As the communication unit (50) passes into cell 25, the BSC (15) by reference to the means for configuring (36) now determines that the lowest-level branch point in the
- 25 signal distribution system is the switch (34) located at the BSC (15). Upon such determination the controller (35) within the BSC (15) commands the switch (34) within the BSC (15) to discontinue the signal path between terminals 1 and $p+2$ and re-establish the signal path through terminals
- 30 1 and $p+1$. The BSC (15) also commands the switch (34) within the target BS (19) to establish a signal path between terminals 1 and $p+3$.

- If, after passing out of cell 25, the communication unit (50) were to pass into a cell (not shown) controlled by BSC
- 35 16 then the serving BSC (15) by reference to the means for configuring (36) would determine that the switch (34) (not shown) within the transcoder (12) is the lowest-level branching point serving both serving (24) and target cells.

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Upon such a determination the serving BSC (15) would transmit a request to the transcoder (12) requesting that the transcoder (12) handoff the communication unit (50) to the target cell.

5 As a further example, a first communication unit (50, FIG. 3), within cell 22, transmits an access request to the serving BSC (15) requesting access to a second communication unit (51) in cell 23. The BSC (15), using
10 prior art paging techniques, identifies the target communication unit (51) as being in cell 23. Upon a determination of the location of both first (50) and second (51) communication units, the BSC (15), in accordance with the preferred embodiment of the invention and by
15 reference to the means for configuring (36), determines that the lowest level branching point serving both cells is the switch (34) located at BS 18. Upon such determination the call controller (BSC 15) transmits a command to the switch (34) establishing a voice path between terminals p+3 and p+2. The BSC (15) also transmits an access grant to the
20 first communication unit (50) on a first frequency (f₁) and an access grant to the second communication unit (51) on a second frequency (f₂). The first (50) and second (51) communication unit, upon tuning to the proper frequencies begin exchanging a communicated signal on their respective
25 frequencies.

During the exchange the second communication unit (51) moves out of cell 23 and into cell 24. The movement of the communication unit (51) is detected by signal strength measurements of control transmission of
30 surrounding cells (22-27) performed by the communication unit (51) and transferred to the BSC (15) through the BS (18).

Upon determination of a need for handoff the call controller (BSC 15) commands the communication unit (51)
35 to handoff to the handoff target cell (24) on the same or another channel (f₃). The call controller (BSC 15) also commands the matrix switch (34) to discontinue the signal

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path between terminals p+3 and p+2 and re-establish a signal path between terminals p+3 and p+1.

5 As a further example, and continuing the above example, the second communication unit (51) may continue to move through cell 24 and into cell 25. As above, such movement is detected by signal strength measurements performed by the communication unit (51) and transferred to the serving BSC (15).

10 The BSC (15) now determines that handoff to cell 25 is appropriate. Determination of the identity of the switch (34) to handoff from cell 24 to cell 25, under the preferred embodiment, is determined by reference to the means for configuring (36) within the BSC (15).

15 Upon reference to the means for configuring (36) the call controller (BSC 15) determines that the matrix switch (34) within the BSC (15) is the lowest level matrix switch bridging the two service coverage areas (24 and 25). Upon reaching such a determination the controller (35) within the BSC (15) commands the switch (34) within BS 18 to
20 establish a circuit path between terminals p+3 and 1. The controller (35) also commands the matrix switch (34) within BSC 15 to configure a path between p+2 and p+1. As a final step the controller (35) commands the matrix switch within BS 19 to configure a path between terminals 1 and
25 p+3.

If the communication unit (51) should continue to move into another service coverage area served by another BSC (16, FIG. 1) then the process would continue. The communication unit (51) would again measure signal values
30 as a means of detecting a handoff target. The serving BSC (15) would identify the lowest level signal distribution point (transcoder (12)) serving both service coverage areas by reference to the means for configuring (36). Upon identifying the lowest level branch between BSCs (15 and
35 16) the serving BSC (15) would forward a handoff request to the transcoder (12).

Upon receiving the handoff request the MSC (10) would transmit routing requests to the switch (34) within

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5 the transcoder (12) (not shown) and to the BSC (16) of the target base site (not shown). The handoff target BSC (16) would, in turn, transmit routing instructions to switches (34) (not shown) of the BSC (16) and handoff target BS (not shown).

10 Inclusion of a switch at each signal branching point provides the benefit of signal handoff at the lowest level, that in the case where the call controller is the BS of both serving and target cells, involves the fewest controllers. The use of switches at each signal branching point allows for greater trunking efficiency by allowing trunked use of interconnect wiring that otherwise would be dedicated to a less flexible, specific function.

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Claims

1. A method of performing handoffs in a cellular communication system, such method including the steps of:
5 providing a switch at each point in a signal path bridging at least two cells; determining that handoff of a communication unit from a serving cell to a target cell is indicated; identifying a switch in a signal path to the
10 serving cell bridging the serving and target cells; and handing off through the switch.
2. The method as in claim 1 further including measuring signal quality factors and determining an indicated need for
15 handoff and an indicated target based, at least in part, upon the measured values.
3. The method as in claim 2 further including
20 transferring the measured values to a call controller of the serving cell.
4. The method as in claim 3 further including
25 identifying, by the call controller, a bridging point based upon an identity of the indicated target and serving cell.
5. The method as in claim 4 further including
30 referencing a look-up table for the identify of the bridging point based upon an identity of the target cell and serving cell.
6. The method as in claim 2 further including measuring
signal quality factors of surrounding cells by the communication unit.
- 35 7. The method as in claim 2 further including measuring signal quality factors of the communication unit by cells surrounding the serving cell.

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8. A method of performing handoffs in a cellular communication system, such method including the steps of: providing a switch at each signal distribution point serving at least two service coverage areas; determining that
- 5 handoff of a communication transaction from a serving cell to a target cell is indicated; identifying a common switch of both serving and target cells; transmitting a handoff request to the common switch; and handing off the communication transaction through the common switch.
- 10
9. The method as in claim 8 further including defining a base station having at least two cells as a signal distribution point.
- 15
10. The method as in claim 8 further including defining a transcoder, transcoding a signal from at least two base station systems as a signal distribution point.

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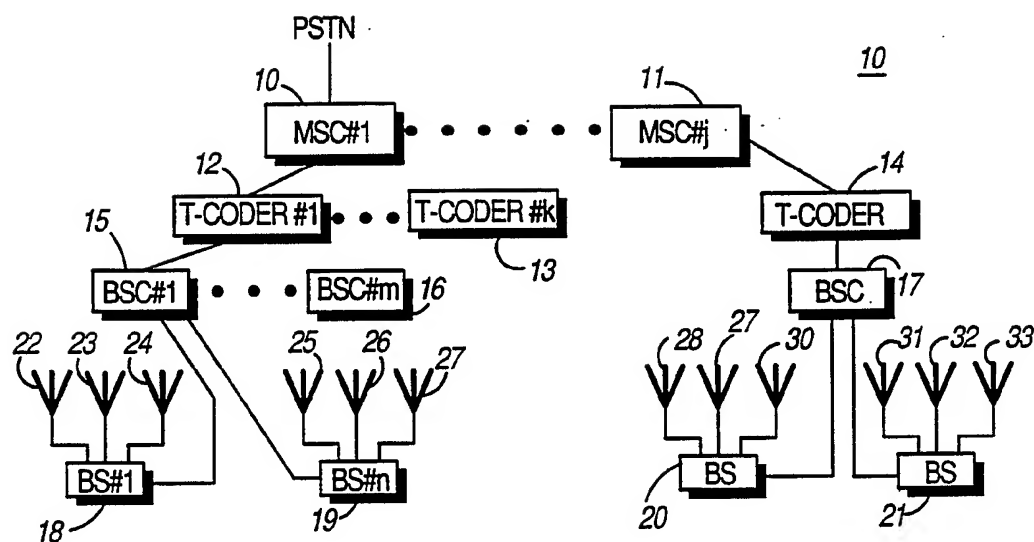


FIG. 1

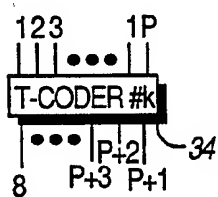


FIG. 2

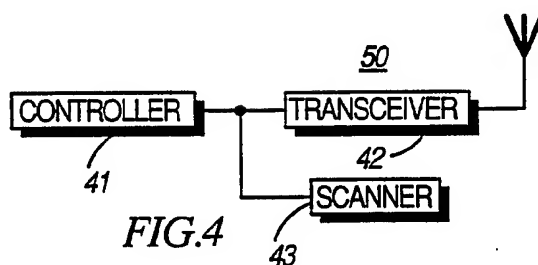


FIG. 4

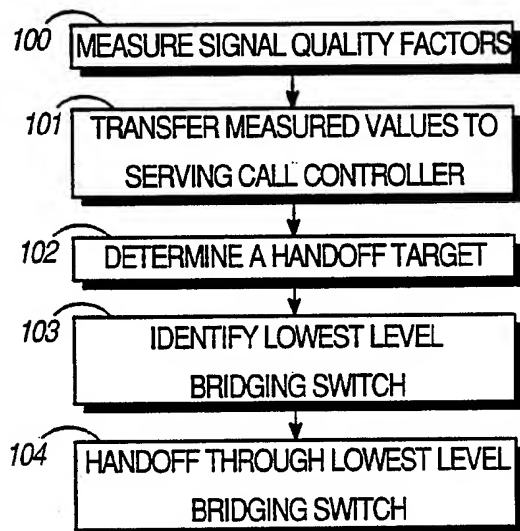


FIG. 5

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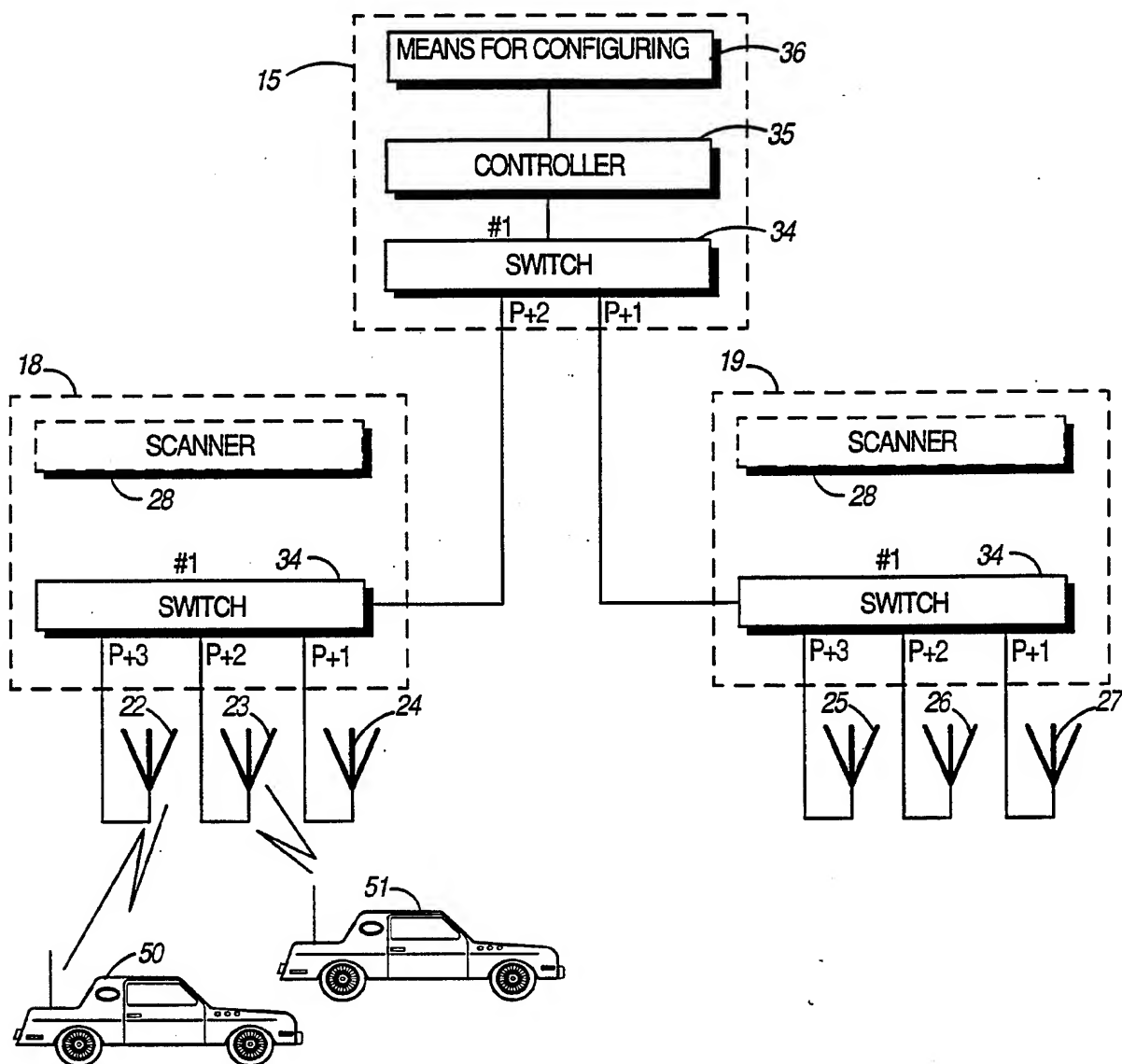


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/05771**A. CLASSIFICATION OF SUBJECT MATTER**IPC(5) : H04Q 7/00
US CL : 455/33.2

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 455/33.2, 33.1, 54.1, 56.1; 379/ 58, 59, 63

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,613,990 (Halpern) 23 September 1986 col. 9, lines 32-56	1-10
X	US, A, 4,870,410 (Andros et al.) 26 September 1989 col. 10, lines 5-28	1-10
Y	US, A, 4,856,048 (Yamamoto et al.) 08 August 1989, Abstract	1-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.


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Date of the actual completion of the international search

01 September 1993

Date of mailing of the international search report

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